EXHIBIT C

Children's Use of Various Internal Automobile Trunk Release Mechanisms Intended to Reduce Child Entrapment Risk

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Abstract

As one part of a three-part package to reduce the likelihood of children becoming inadvertently trapped in automobile trunks, an internal trunk release mechanism was developed that would be obvious to young children as a way to open a locked trunk from the inside. Eighty-one children between the ages of three and seven voluntarily entered several disguised automobile trunks that had been separated from the rest of the vehicles and instrumented with audio and video monitoring equipment. The children attempted to find a way out of the trunk with no instructions about how to accomplish the task. Nine different mechanisms ranging from pull cords to light switches and door handles were examined. The most successful mechanism was found to be a yellow, lever-type door handle. This paper describes the development procedure and the responses of the children to the different mechanisms.

Introduction

Fatal trunk entrapments of children occur rarely. However, during the summer of 1998, eleven young children in three separate incidents were unintentionally trapped in motor vehicle trunks with fatal consequences. To reduce the likelihood of these events, a three-part trunk retrofit system was developed. It consists of a lever-style handle mounted inside the trunk to open the trunk, a trap-resistant latch to make it more difficult for children to close the trunk, and a fastener to make it more difficult to gain access to the trunk through fold-down rear seats. The three-part system can be installed in most General Motors passenger cars for model years 1990 to the present.

This paper presents the results of the human factors testing that guided decisions regarding the characteristics of the interior trunk latch release mechanism ultimately selected.

Method

Three vehicles, a 1997 Chevrolet Cavalier, a 1997 Pontiac Grand Prix, and a 1997 Buick Park Avenue were used for testing. Their trunks differed in shape, size and interior finish. The trunks and rear seat assemblies were separated from the rest of the vehicles and the tires removed. The trunk exteriors were disguised. Each trunk interior was instrumented with infra-red cameras and a microphone to monitor children during the test.

Participants in the study were primarily between the ages three and six and lived in the San Francisco Bay Area. Children were selected whose parents believed they

would not be afraid to be shut in a small, dark enclosure. Children who had a history of being in trunks, for example, getting in to hand groceries to a parent, were excluded.

Children were not told they were getting into a trunk nor the specific purpose of the project, only that they were to try and get out. During testing if a child or parent became uncomfortable, testing was stopped. If a child was not able to activate the release mechanism within five minutes, the test was stopped. Test procedures were reviewed and approved by members of the Exponent Human Subjects Testing Committee prior to beginning testing.

Testing was conducted in a location free from distractions and unfamiliar to the subjects. Upon arrival at the test site, children were allowed time to become familiar with the surroundings and with the experimenters. Each child initially sat at a child-size table with one experimenter where a choice of activities was offered (e.g., coloring books, puzzles, modeling dough), while a second experimenter showed the parents the trunk and other activities, answered questions, and obtained a signed informed consent form. After leaving the activity table, subjects crawled through darkened, fabric-covered tunnels and participated in a ball toss activity.

Children were then presented with the trunk task. Children were told that they would be helped inside, that the experimenter would close the top, and that their job was to get out. Children who did not want to enter the trunk were informed that cameras and a microphone allowed their parents and the experimenters to see and hear them while they were inside. Some subjects were given the option of having a parent or an experimenter inside the trunk with them.

Each child received a teddy bear and the family was given a monetary reimbursement of $75. Children who recognized the trunk were told about the hazards of getting into trunks. All parents were told about ways to keep children out of trunks and unattended motor vehicles in general, and given several child safety brochures to take with them.

Nine different forms of release mechanisms were tested that differed in color, material, size, shape, and in the direction and type of movement required of the user. The general form of the mechanisms included the following: a glowing cable; an orange, plastic D-shaped handle; a red, rubber, wagon-style handle; a green, plastic 2.5 inch diameter knob with a knurled outer edge; a standard, white, light switch; a silver-plated, toy key; a gray, plastic, interior, car-door handle; shorter (about 3 inches) lever-style handles; and longer (about 7 inches) lever-style, door handles. The lever-style handles were tested in several different colors, shapes, and materials. All release mechanisms were illuminated by small, directional, light-emitting diodes (LEDs), except the glowing cable, which was illuminated internally by a fiber optic light panel.

Release mechanisms were tested and then replaced or modified based on observations of the interaction between subjects and the device and the performance of the device once installed. Some mechanisms were tested with very few subjects because of the response of the children to the device or the experimenters' judgements about the function of the design.

Results

Of the 93 qualified subjects who appeared for the testing, 12 (13%) refused to get into the trunk, 30 (32%) entered with another person, and 51 (55%) entered by themselves.

The glowing cable was hung from the lid of the trunk and its intended use was in the manner of a pull cord on a city bus. Subjects were hesitant to touch the cable and certainly did not grasp and pull it. In response to questions after the tests, subjects indicated that they thought the glowing cable was a light or something electrical.

Both the orange handle, which was mounted vertically, and the red handle, which was mounted horizontally, allowed children to use a power grasp. Two LEDs shining on the handles made them easily visible. The orange handle was initially installed such that it allowed some movements that would not result in opening the trunk. Subjects who moved the handle in these directions and did not achieve success were likely to discount the device as one that would open the trunk. For some

subjects, the intended proper motion of pulling the orange and red handles toward themselves was not obvious as being the appropriate direction to move the handle. Other subjects aggressively grasped and pulled the handles.

The green knob was easily visible. The surface characteristics and the frequency of the knurls along the outside diameter of the knob did not provide an appropriate interface for children to utilize a palmar grip. Only a five-finger grasp was possible. Based on anthropometric data, some young children would not have sufficient dexterity and strength to turn this knob easily.

With the shorter lever handles and the interior car door handle, the size and clearances forced the subjects to use only their fingers to activate the mechanism. The gray, plastic, car-door handle was easily visible, but the silver surface of the chrome lever was difficult to make visible using the two LEDs. The behavior of subjects who explored and attempted to manipulate these handles was, in general, more tentative relative to handles that operated by using a power grasp.

The light switch was tested as a release device in response to previous test subjects indicating that they needed more light to find their way out. The hypothesis was that subjects would use the light switch in an attempt to gain more light for their task. Flipping the switch opened the trunk. Subjects questioned after the test recognized the device as a light switch, but during the tests they were hesitant to use the switch and behaved as if they did not associate it with the task of getting out of the trunk. Additionally, some subjects indicated that they had sufficient visibility and did not require additional light. In certain trunks and in certain external lighting conditions, the interior of the trunk may have sufficient ambient light so that a subject might not consider flipping a switch for more light.

The toy key was installed to dangle on a cable near the latch. Pulling the key would open the trunk. This device was tested based on the theory that children would associate keys with unlocking doors. The chromed surface, which we believed might be an important cue for children in identifying an object as a key, was a difficult surface to make visible with the lighting inside the trunk. For children, handles and not keys had stronger associations with being a device to use to get out of a trunk even though children were able to identify the object as a key.

The longer, lever-style, door handle was oriented horizontally above the latch mechanism. Its visibility was adequate, but the brass surface did not provide the best contrast and produced some bright spots of reflected light. Visibility was improved when matte surfaces were used. A clockwise rotation was required to operate the handle, and children who operated this handle generally used a power grip and arm movement to rotate the handle. The response of the children who operated this style of handle was much quicker and more aggressive relative to the other styles of handles tested.

Discussion

Our testing involved children entering the trunk primarily through the trunk-lid opening. In a limited number of tests, subjects entered the trunk via the rear seat. Subjects tended to search for a way to get out in the area around the latch. Exceptions to this practice were when they worked on areas where light entered the trunk (e.g., speaker openings, seat cushion-seat back junctions), tried to unscrew the cover for the spare tire, or worked their hands around or into openings in the body panels.

The use of light was important in guiding children to the release mechanism. The release mechanism itself should not resemble an electrical cord or a light. The lighting cannot make the mechanism appear to be hot or glowing. Lighting a large portion of the trunk, rather than only the release device, appeared to provide too comfortable a space for children and eliminated the use of light as a cue for directing attention to the release mechanism. The mechanism needs to be a color that contrasts with its surroundings and to have a matte finish, not glossy, to achieve even illumination.

Mechanisms that involved intervening tasks, such as the light switch, or more cognitive associations, such as the key, did not work as well as mechanisms that were handles.

The handles, most of which were located near the latch on a vertical surface of the trunk, differed in the degree

to which children understood the appropriate direction they were to move them. Children were generally quick to apply a clockwise rotation to the larger, lever-style door handle, whereas the other handles that required pulling the handle toward them were less often tried.

Subjects performed better with release mechanisms in which they could use their entire hand and arm to generate movement and force, rather than with smaller mechanisms that only permitted use of their fingers. If the design of the release mechanism permitted motion in a particular direction, then that motion must open the trunk. Otherwise, there was a strong possibility that the children would not return to try the mechanism in that or another direction. The mechanism had to move silently and smoothly. Noisy or irregular movement caused subjects to stop trying the mechanism.

The production version of the larger, lever-style door handle incorporates a matte yellow finish on a contrasting matte-black surrounding escutcheon with integrated lighting that illuminates the handle surface. The design allows children to see the surface of the handle without creating the appearance of hot spots or electrical shock. It includes a handle shape and size that children tended to recognize, without instruction, as one to use, grasp, and rotate. Children have sufficient strength and dexterity to activate the mechanism.

Some children sat in the trunk taking little or no action to get out themselves, even when encouraged to try by the experimenter or their parent. The presence of a handle inside the trunk will not eliminate the risk of trunk entrapments for all children. The inclusion of a trap-resistant latch intended to make it difficult for children to lock the trunk-lid and the closure to make it difficult to gain access to the trunk through the rear seatback are important additional components to reduce the risk. The three-part trunk retrofit system will not, however, replace the need for parents to take prevention measures to keep children out of unattended motor vehicles.

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